SPECTRUMASTRO

Network Hardware for LEO Spacecraft

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SPACE NETWORK HARDWARE DEVELOPMENT

Spectrum Astro is Developing Space Network Hardware for NASA:

- Space Network Devices (SND) Program
- TCP/IP Router Board (TRB) Program

Benefits of Using Network Standards Onboard Spacecraft:

- Reductions in Costs and Schedule are Realizable With Use of Open-System Standard Interfaces
  - Costs Minimized Over Spacecraft Life Cycle
  - Facilitates Rapid Design and Development Effort
  - Testing and Integration Schedules Can Be Compressed
  - Space Applications Leverage from Huge Investment in Terrestrial Commercial Off-The-Shelf (COTS) Technology Development
  - Technology Already Extensively Tested Before and After Commercial Deployment
- Provides Robust, Fault-Tolerant Architecture
- Onboard Use of Network Protocols at Layers 1 and 2 is a Building Block to Seamless Internet-like End-to-End Connectivity For All Aspects of Space Communications (Space – Ground, Onboard, and Constellation)

SPACE NETWORK HARDWARE DEVELOPMENT

SND (Space Network Devices)

- Customer: NASA/CICT/SCP
- Technical Manager: Robert Jones (NASA GRC)
- TRL 1 - 3
- Goals:
  - Perform Trade Study of Ethernet, FireWire, and SpaceWire Technologies for Use Onboard Spacecraft
  - Develop Prototype Network Hardware for Unmanned LEO Spacecraft
    - » Ethernet Network Controller
    - » Ethernet Hub
  - Identify Transitional Architectures to Move From Spacecraft Busses of Today to Next-Generation Networked Spacecraft

SPACE NETWORK HARDWARE DEVELOPMENT

TRB (TCP/IP Router Board)

- Customer: NASA ESTO
- Technical Manager: Robert Jones (NASA GRC)
- TRL 3 - 6
- Goals:
  - Develop a Single Board Ethernet Router With Embedded Processor for Use in Unmanned LEO Spacecraft
  - Take Technology Developed Under SND and Transition From Prototype to Flight Hardware

DESIGN CHALLENGES

Challenges to Designing Space Electronics Based on Terrestrial Network Standards:

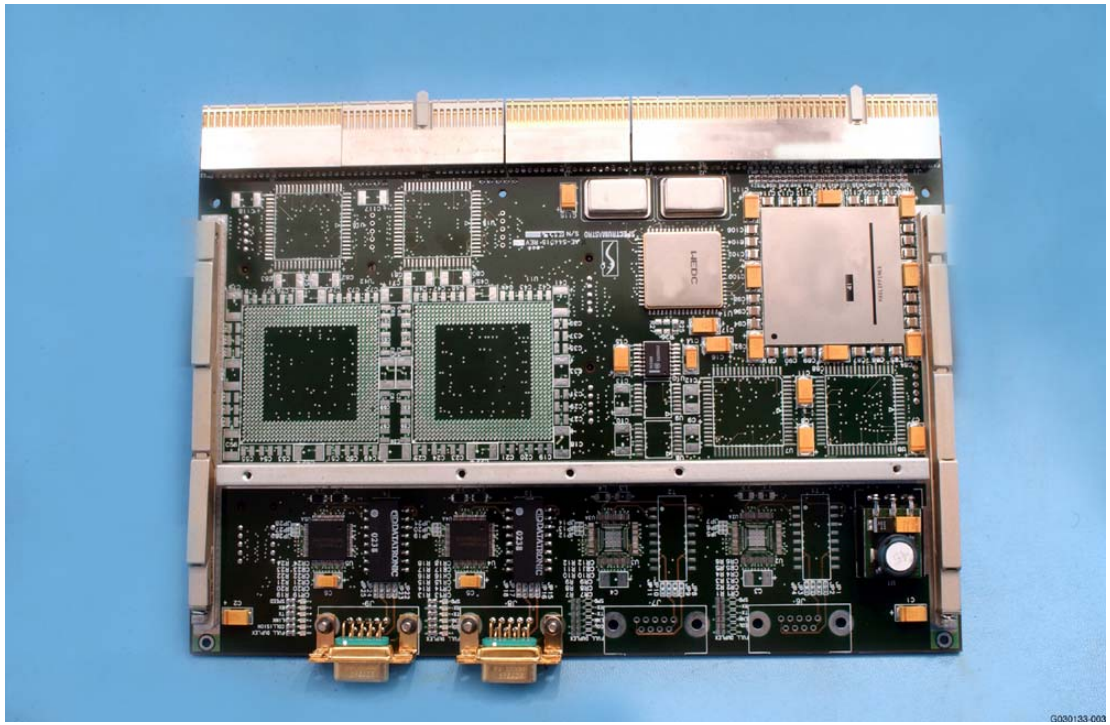
- Identifying Parts That Will Meet Space Requirements When Most Parts for LAN Interfaces Are Manufactured for Commercial or Industrial Market at Best
- Identifying Parts Not Expected to Reach End of Life in a Relatively Short Time
- Establishing a Good Working Relationship With Commercial Parts Suppliers
- Determining Approaches to Mitigate Risk, Such As RAM Scrubbing

Our Approach:

- Use Military/Space-Rated Parts in Design Where Possible and COTS Parts Elsewhere
- Validate Use of COTS Parts With Testing and Analysis (Radiation, Thermal Cycling, Etc…)
- Identify and Perform Tests That Verify the Design as Well as Manufacturing Processes
- Identify and Address Issues As Early As Possible in the Design Cycle

ETHERNET NETWORK CONTROLLER

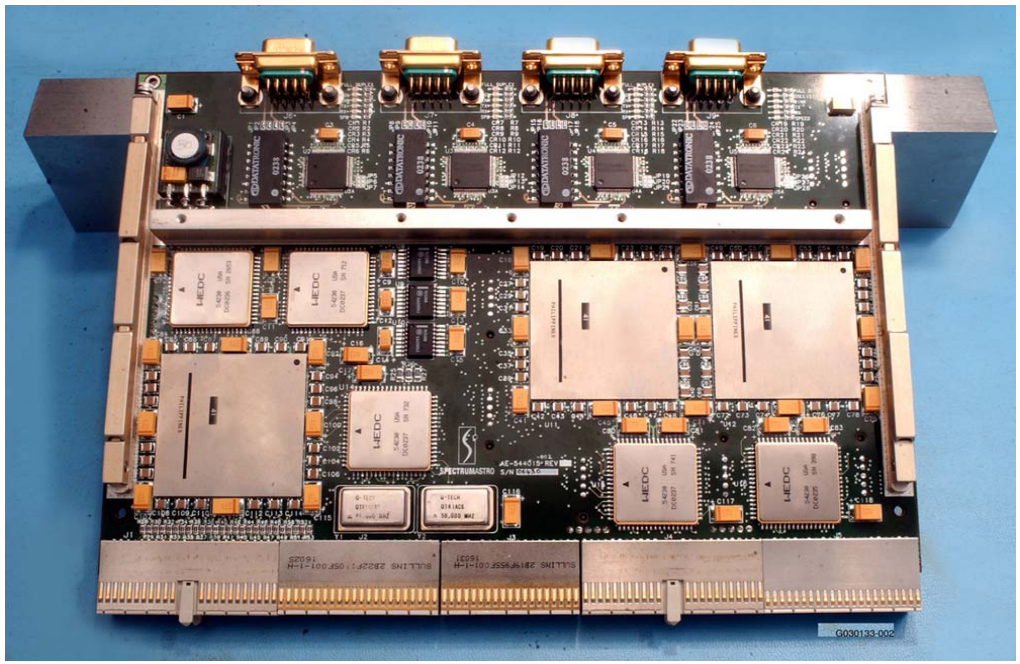
SPECTRUMASTRO



Ethernet Network Controller Features:

- 10/100 Mbps
- cPCI Interface
- Up to 4 Separate NICs
- Up to 2 Dual-Port NICs for Redundancy
- Supports Cable Lengths Up to 100 Meters with CAT-5 Cable
- Network Connections to Either Front Panel D-Sub 9 or to cPCI Backplane By Jumper Selection
  - cPCI Supports 10/100/1000 Ethernet Over Backplane in cPSB Standard PICMG 2.16
- D-Sub 9 to RS-45 Adapter Available from Most Common Electronics Suppliers

ETHERNET HUB



Ethernet Hub Features:

- 100 Mbps Repeater
- Integrates in cPCI Chassis
  - Could Be Implemented on Other Standard Backplanes
- Uses Standard +3.3 Volt and +5 Volt Supply Voltages From cPCI Backplane
- Prototype Has 4 Ports
- Partition Options Are Enabled for Robustness
- Network Connections To Either Front Panel D-Sub 9 or to cPCI Backplane By Jumper Selection
  - cPCI Supports 10/100/1000 Ethernet Over Backplane in cPSB Standard PICMG 2.16

TCP/IP ROUTER DEVELOPMENT

Spectrum Astro Responded to the AIST NRA With a Proposal to Develop a Space Router

- Topic Area: Onboard Data Processing
- Subtopic Area: High Speed Intra-Spacecraft Communications Bus

Studies

- Routing Protocols
- Embedded/Flight Processor Use Comparison
- Console Port Implementation
- Spacelink Protocols (Uplink/Downlink/Crosslink)

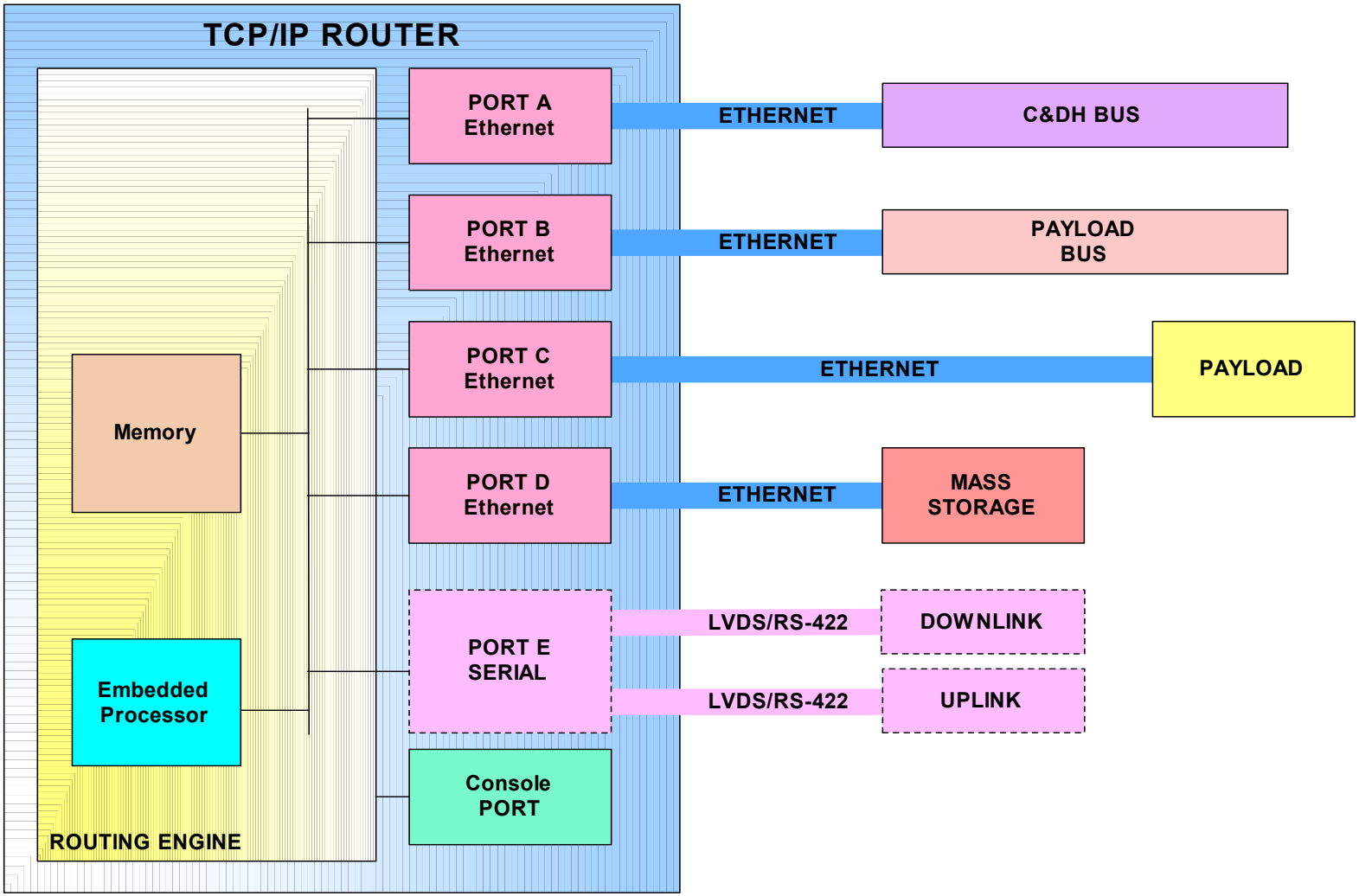
New Hardware Development

- Console Port
- Embedded Routing Processor
- Board Tested to Thermal and Mechanical Qualification Levels

New Software Development

- Routing Software Running on Embedded Processor

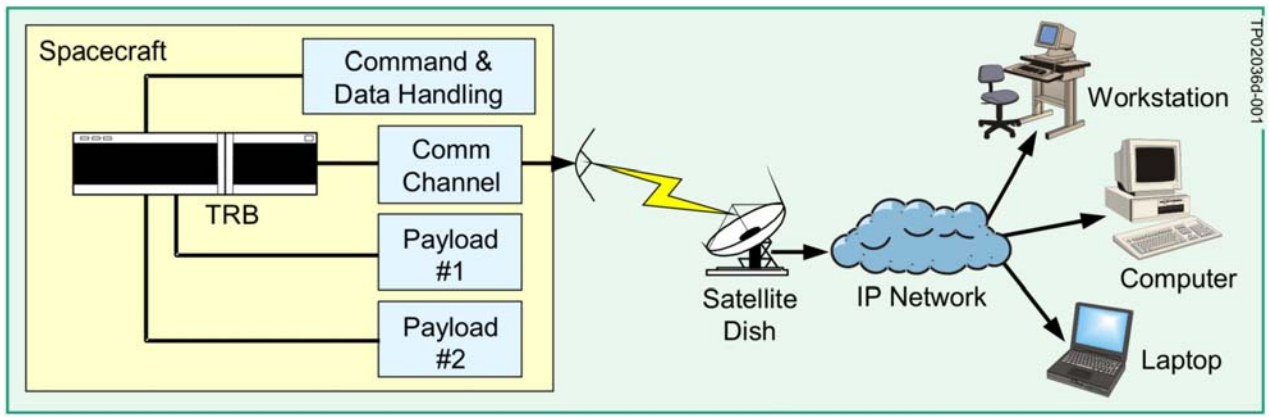
TCP/IP ROUTER



TCP/IP ROUTER

Relevance to Earth Science Enterprise (ESE) Programs

- NASA Acquires, Processes, and Delivers Large Volumes of Remote Sensing and Related Observations
- An Advance in Information Technology (IT) Is Key to Collecting, Handling, and Managing That Data and Information in Space as Well as on the Ground
- Router Allows Increased Accessibility of Earth Science Data By Providing Direct Path to Instruments
- Router Provides a Means to Isolate the Data Requirements While Providing a Selective Path for Communications Between LANs



Conceptual Space-to-Ground Spacecraft Implementation

SPECTRUM ASTRO

Spectrum Astro Is a Contractor Who Builds Spacecraft for NASA and the DoD

Our Goals

- **Providing Competitively Priced Products**
- **Providing Reliable Schedules**
- **Improving Integration and Test**

How We Achieve These Goals

- **Use of Open Standards As Much As Possible**
- **Limit Custom Hardware or Software Interfaces**
- **Use COTS Test Equipment to Avoid the Cost and Schedule Hits of Designing and Building Custom Test Equipment**
- **Flexible Architectures**

Spectrum Astro Was the First Aerospace Company to Fly a Bus Based on a Terrestrial Standard (VME)

Use of Open Terrestrial Standards Like TCP/IP and Enabling Technologies Such as Ethernet Are Part of the Evolution For Next-Generation Spacecraft

CONCEPTUAL TECH DEMO BLOCK DIAGRAM

SPECTRUMASTRO

Allows Operational Programs to Select and Use Technology Without High Risk Penalty

First Technology Demonstration Flight -> Secondary Payload on a Host Spacecraft

Attitude, Power, Mechanical, Thermal Support From Host